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AUTHOR Warnat, Winifred I.
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ABSTRACT

Robotics (robot usage) is discussed from a historical perspective with regard to its role in employment and education. Part 1 examines the transition from an industrial to an information society and speculates what the future might hold, particularly in terms of employment. Part 2 gives a historical overview of the robotics industry and discusses the industry's impact on work and its anticipated growth, specifically in Michigan, Part 3 investigates the role of robotics in education. Findings from the U.S. Congress Office of Technology Assessment Report are used to look at problems facing American education in its efforts to respond to the information revolution. It is suggested that, to narrow the education-technology gap, schools need to work on student skills which focus on process rather than subject matter content. Process skills noted include critical thinking, problem solving, creativity, application, synthesis, communication, and evaluation and analysis. Various ways to incorporate these essential skills into the classroom are also mentioned. (JM)

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ROBOTICS: A BRIDGE FOR EDUCATION AND TECHNOLOGY

Winifred I. Warnat, Ph.D.
Director

National Center on Teaching and Learning
Eastern Michigan University
Ypsilanti, Michigan

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Table of Contents

		Page
	Introduction	1
I.	A Society in Transition	2
	Future Employment Picture	3
	Expectations	5
II.	The Robotics Industry: The State of the Art	6
	Historical Overview	6
	Impact on Work	9
	Anticipated Growth	10
	Robotics in Michigan	12
III.	The Role of Robotics in Education	15
	The OTA Report	16
	The Education Picture	18
	Challenges Facing Public Education	23
	High Tech Firms and Public Schools	26

ROBOTICS: A BRIDGE FOR EDUCATION AND TECHNOLOGY

Introduction

I am delighted to be here with you today. Some of you know that I am relatively new to Michigan, arriving less than two years ago from Washington, D.C. Since then my suspicions have been confirmed--Michigan is truly an exciting state to be in and to be a part of. Much of my attraction to the State was based on the rumblings of high tech and robotics Michigan was beginning to make while I was still in Washington. That triggered my curiosity. Upon my arrival, my interest was spurred by attending the "great" robot conference of 1982 held at Cobo Hall in Detroit last March. Nearly 25,000 people showed up at the exhibit--students were turned away. It was exciting! What distressed me as a conference attendee, was the lack of education involvement (schools) at the conference. Only one speaker attempted to relate robotics to schools and ended up intimidating and turning off the audience. That concerned me! From that experience, I became determined to try my best to see if a connection could indeed be made between robotics and schooling. It did not take me long to discover the world was mine to conquer. So here I am today, nearly one year later, beginning to make the connections.

My discussion today is divided into three parts. In Part One, I will examine our transition from an industrial to an information society and what the future might hold. In Part Two, we will take a look at the world of robotics and what it means to Michigan. And in Part Three, I will discuss the role of education in robotics and how robotics can further the connection of schools with high technology. One critical dimension of the social changes taking place undergirds my talk--the impact of technology, especially robotics, on the changing nature of work.

I

A Society in Transition

While the revolution from an agricultural to an industrial society took 100 years, the present restructuring from an industrial society to an information society has taken only 20. Because of the rapidity with which this second revolution has occurred, adaptation to the social changes taking place has been difficult. Indeed, it appears that the American economy has changed before its thinking has. The information revolution has had major influence on dramatic changes taking place in the workforce--the most obvious being the mounting number of displaced workers. Like those of the 1930s, primarily out-of-work farmers unequipped for the emerging opportunities in factories, today's wave of displaced workers also lacks the skills or education needed to obtain emerging jobs, this time in computers, engineering, and advanced technology. There is general acknowledgment that the revolution has occurred; we are in the post-industrial society; and blue-collar work is being replaced by knowledge technology.

The rapid movement toward the automated factory is representative of the impact the new technologies are having on our workforce. It will affect American jobs and jobholders on an unprecedented scale. A radical restructuring of work, including a devaluation of current work skills and the creation of new ones at an ever-increasing rate can be expected. The fundamental changes occurring in the workplace will make it necessary for employers to retrain hugh numbers of workers. The Nation's education system will have to become more responsive to the demands of the workplace in preparing future workers for functioning in a high tech information society. It is estimated that 45% of all jobs (45,000,000 out of 100,000,000) will be affected by automation by the year 2000.

An April, 1982 Census Bureau report confirmed the fact that the Nation has moved from a production-based economy to a service-based economy. That conclusion was based on the fact that only 20% of U.S. workers are now involved with the manufacturing of products, while 65% are providing informational services. The most essential resources identified in this service-based economy is educated people.

Future Employment Picture

In the summer of 1982, a Congressional Budget Office report stated that by 1985 automation would eliminate 200,000 auto production jobs. It would reduce the steel work force by 2 to 3% through 1990. By the year 2000, industrial robots could eliminate 7 million jobs. On the other hand, by the 1990s, 14.5 million new jobs are expected to be available.[1] (See Figure 1)

Figure 1

NEW OCCUPATIONS FORECAST FOR THE 1990s

Occupation	Available Jobs
Industrial Laser Process Technician	2,500,000
Battery Technician	2,500,000
Housing Rehabilitation Technician	1,750,000
Industrial Robot Production Technician	1,500,000
Energy Technician	1,500,000
Hazardous Waste Management Technician	1,500,000
Paramedic	1,300,000
Geriatric Social Worker	1,000,000
Materials Utilization Technician	500,000
Holographic Inspection Specialist	200,000
Bionic-Electronic Technician	200,000
Genetic Engineering Technician	150,000
Total Jobs Forecast	14,500,000

There is much promise if these occupations actually appear in the numbers forecast. However, the nature of these occupations make glaringly evident this is not an unskilled or semi-skilled work force we are talking about. The dilemma we are facing in this period of transition from an industrial to an information society is due in large part to the fact that we have no national employment policy.

More about what the future might hold--by the year 2000 the factory assembly line will be a thing of the past. Japan will continue to have the largest robot population with over 11,000,000 by the turn of the century. In the United States, big business will grow even larger, dominating the markets of the new technologies and services. General Motors will make small, fuel-cell powered cars for local travel and buses for mass transit in congested urban areas. While GM will remain profitable for many years, by the year 2010 it could vanish from the leading ranks of corporate conglomerations.[2]

The population changes taking place also will have a dramatic impact on the workforce of our information society. A recent U.S. Census Bureau Report has projected the following changes in composition.[3]

- A dramatic increase in the median age of Americans from 30.3 years in 1981 to 36.3 years by the year 2000.
- There will be a precipitous decline in the number of teenagers from 27.6 million in 1981 to 24.4 million in 1995.
- There will be a dramatic increase in those over the age of 65 from 26.3 million in 1981 to 34 million in the year 2000.
- There will be a population bulge of Americans 35-64 years of age with 70.4 million in 1981 to 104.5 million in 2000.
- The college age population will shrink from 17.5 million in 1981 to 14.6 million by the year 2000.
- The U.S. population, now 232 million, will expand by less than 1% to the year 2000 with growth possibly ceasing and peaking at 309 million by 2050.

For the American workforce, these population changes will result in fewer young workers, more middle-aged workers, and a declining number of workers overall. Further, these trends suggest that unemployment will subside as a persistent problem. We simply will not have available today's number of workers. Enrollments in secondary schools and colleges will decline. And productivity as a result of automation, and subsequently competition of U.S. businesses will escalate.

Expectations

What else might we anticipate as a result of the new technologies? We can anticipate that the need for workers will dwindle as machines take over more and more of the work of humans. There will be a restructuring of the work week, which might be reduced from five days to four to accommodate the reduced need for workers. Such a change has not occurred in almost a century. There will be an adjustment in compensation for work. Hourly wage is likely to be eliminated and replaced by salaried compensation. High tech jobs can be expected to increase by 50% by the end of this decade. The government will reassess and take measures to address the social impact of the high technologies, which so far it has grossly underestimated. The manufacturing industries will become increasingly service oriented. The information/service economy will become even more highly skilled and filled with knowledge workers. The role of education in preparing the workers of the future and keeping the knowledge and skills of the current workforce up-to-date will expand dramatically.

II

The Robotics Industry: The State of the Art

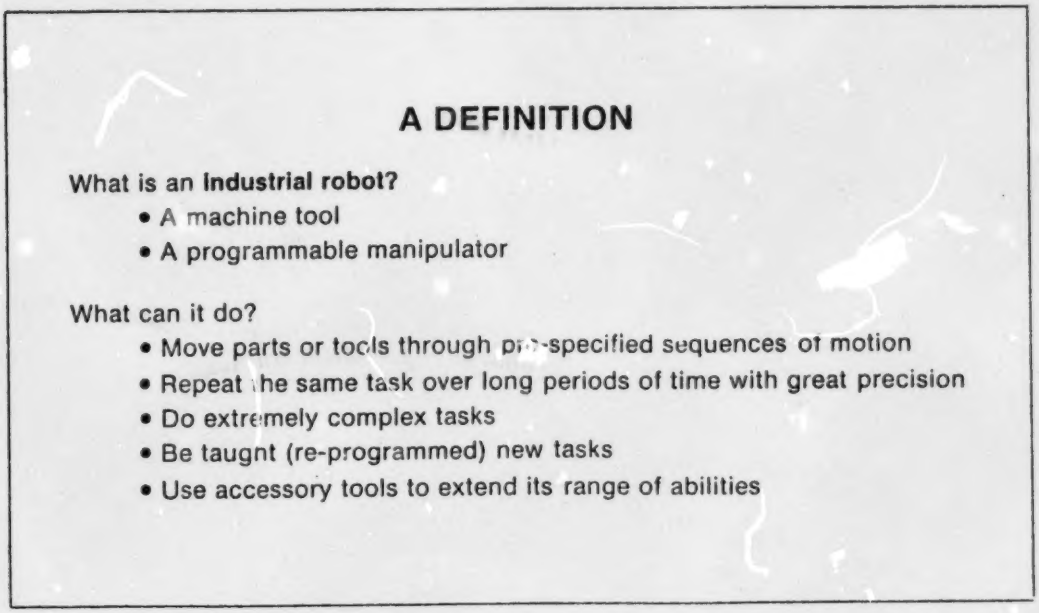
The three major new growth industries to develop over the next 20 years are (1) telecommunications, (2) biotechnology, and (3) robotics. One dimension of the robotics industry, frequently overlooked, relates to its projected impact on the Nation and worldwide. The developing diversification of the industry provides explanation for its classification as one of the three major new growth industries. Industrial robots, dominating the scene these days, represent only one part of the robot industry. Expansion of the industry also includes the following categories of robot development already underway: nuclear robots, medical robots, mining robots, genetic robots, underwater robots, space robots, entertainment robots, education robots, and household robots. These are the things to come. Already two household robots are on the market for us consumers to take advantage of. We can buy them assembled or in kits to put together. This was not supposed to happen for twenty years. We need to question the predictions we are hearing--technology seems to be advancing at a much more rapid rate than we are able to anticipate.

Historical Overview

While the reality that the robotics industry is much more expansive than first appears, today the greatest attention is given industrial robotics. A definition of industrial robots is presented in Figure 2. For a brief review of its history, the term robot was popularized by Czech playwright Karl Capek in his 1921 play R.U.R. (Rossum's Universal Robots), although the concept of programmable machinery dates back to eighteenth-century France, where mechanical looms controlled by punch cards were developed. In the United States, the concept appeared in the mid-nineteenth century when a programmable lathe that

made screws, nuts, and gears was invented by Christopher Spencer. While the first programmable paint spraying machine was developed in the United States in 1939 by Harold Roseland working for DeVilbiss, the man credited with inventing the industrial robot is entrepreneur George Devol. In 1946 he began the robotic age by developing a general-purpose playback device for controlling machines. In 1954, he patented "universal automation", "unimation" for short, a concept involving some 40 patents in all.[4] More about robot history is provided in Figure 3.

Figure 2


A DEFINITION
What is an industrial robot?
• A machine tool
• A programmable manipulator
What can it do?
• Move parts or tools through pre-specified sequences of motion
• Repeat the same task over long periods of time with great precision
• Do extremely complex tasks
• Be taugnt (re-programmed) new tasks
• Use accessory tools to extend its range of abilities

As to the manufacturing of industrial robots, in 1960 Unimation, Inc., the world's largest manufacturer of robots today, was formed, setting off the production of first generation robots--those with computerlike functions, but permanently wired to perform specific sets of tasks. Second generation robots--those that are software controlled with rudimentary sen-

sory capabilities--were not commercialized until the early 1970s. The first robot controlled by a microcomputer was offered by Cincinnati Milacron in 1974. And in 1977 the first microprocessor-controlled, electronically activated robots were offered by Asea. The six leading industrial robot manufacturers in the United States today are Unimation, Cincinnati Milacron, DeVilbiss, Prab, Asea, and Copperweld.

Figure 3

A ROBOT CHRONOLOGY

Despite some breakthroughs, decades of research have failed to produce an intelligent, independent robot.

1921 A Czech play, Rossum's Universal Robots, opens in London, popularizing the word robot, meaning forced labor.

1939 First programmable spray-painting machine.

1946 The first computer is built at the University of Pennsylvania.

1959 Planet Corp. builds and sells the first commercial robot.

1962 General Motors Corp. installs its first robot in a factory assembly line.

1965 An aluminum robotic hand is developed in Yugoslavia.

1968 SRI International builds first so-called intelligent robot with a TV camera, touch sensors and range finder.

1973 A computer-operated robot puts together 10 automobile water pumps; the first mini-computer-controlled robot appears.

1976 First robot-vision and speech-recognition systems are introduced.

1977 Machine Intelligence Corp. sells first robot with vision.

1980 The Robotics Institute opens at Carnegie-Mellon University; a mobile robot navigates a simple obstacle course.

1981 Neiman-Marcus Co. advertises a primitive robot that uses remote control to open doors, take out the trash, bring in the paper and sweep the floor.

1982 Carnegie-Mellon introduces a second generation robot that's 10 times faster than previous models and has three-dimensional vision; Toshiba Corp. of Japan introduces a camera-equipped robot arm capable of complex tasks.

Source: USA Today

The race is on to develop the second generation of robots. While these robots will not yet "think" like people, they will possess artificial senses

and advanced data processing capabilities. Vision is considered key to the next generation, along with advances in artificial intelligence. Even though most original research and development efforts have occurred in the United States, leading contenders in developing robotic sensory systems include Hitachi, Texas Instruments, International Business Machines, General Motors, and Renault. Most work on artificial intelligence is being conducted by research firms in Silicon Valley. The next step toward "thinking" robots will be to integrate sensory systems with more sophisticated computer software, allowing robots to make limited decisions.

Impact on Work

What impact will robotics have on the changing character of work? The Society of Manufacturing Engineers predicts:

- by 1985--20% of the labor force employed in the final assembly of automobiles will be replaced by automation;
- by 1985--vision systems will provide enough feedback for robots to select parts scrambled in a bin;
- by 1987--15% of all assembly systems will use robot technology;
- by 1988--50% of the labor in small component assembly will be replaced by automation;
- by 1990--the development of sensory techniques will enable robots to approximate human capability in assembly.

Initially, robots were thought of as replacements to do undesirable, hazardous jobs, but increasingly they are moving into more desirable, skilled occupations. New technology is making it possible to replace more highly skilled workers. This trend can result in the stratification of workers into two categories: (1) those with managerial and highly skilled training; and (2) those at entry level, who are unskilled and semi-skilled. The top band of the social strata will consist of the growing number of knowledge workers, while the lower band will consist of a growing number of

workers unable to qualify. The middle band, our middle class, will become increasingly amorphous.

Over half of all unskilled and semi-skilled workers in jobs that could be replaced by robots are in the five major metal working industries (primary metals; fabricated metals; machinery, except electrical; electrical and electronic equipment; and transportation) and half of the production workers in those industries are located in the industrial Midwest. The picture is further complicated by the fact that a vast majority of manufacturing workers still have 20 or more years of active work life left. As of 1980, between two-thirds and three-fourths of these workers were under age 45, which means that barely a third of that workforce will have retired by the year 2000.[5]

The big winners in the rush to robotize the factories in the United States will be the Nation's women. The rise of robots means that factory jobs will no longer require muscular strength and the ability to tolerate noise and dirt on the job. By the year 1990 women will comprise one-third of the Nation's blue-collar work force; by the year 2000 they will make up one-half.[6]

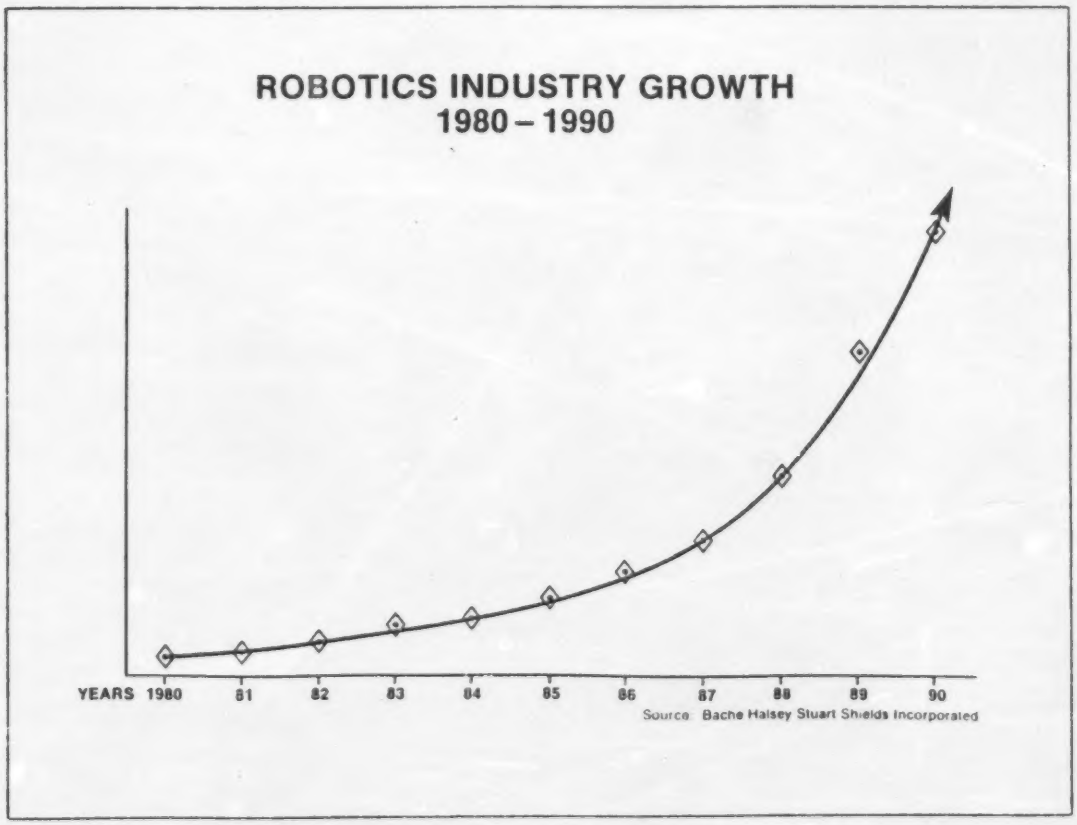
Anticipated Growth

For all the excitement and bustle of activity generated by the industrial robot rage going on the past few years, this industry too, has suffered from floundering national and global economies. However, even though growth estimates have not been met, the future continued impact of the industry on our changing society should not be underestimated.

Laura Conigliaro, Wall Street analyst on the robotics industry points out, in 1978 the entire United States based robot industry had sales of only $60 million. By 1980 the industry with $100 million in sales was con-

siderably larger, but still an infant, especially when compared to the $2.6 trillion U.S. Gross National Product for that year. In 1981, $200 million in sales was projected, only $170 million was reached. The industry is far from being on the downhill slide. New robot manufacturing firms continue to appear, although the vast majority will not succeed. Also, an increasing number of small successful firms are being purchased by the larger conglomerates--Westinghouse's purchase of Unimation being the latest. Conigliaro states, "...whether erratic or smooth, the growth trend for the industry... will be extremely impressive" throughout the decade.[7] (See Figure 4) Keep in mind that Ms. Conigliaro is referring to industrial robot manufacturers; not to companies using robots in manufacturing.

Figure 4


ROBOTICS INDUSTRY GROWTH
1980 – 1990
YEARS 1980 81 82 83 84 85 86 87 88 89 90
Source: Bache Halsey Stuart Shields Incorporated

Robotics in Michigan

Can robotics, industrial robotics in particular, be the salvation of Michigan? In 1981, former Governor Milliken announced Michigan was to become the Nation's center for robot manufacturing. Today, the State can boast that Michigan is in the lead with nearly 40 robot manufacturers, representing more than 50% of the Nation's robot manufacturers located in this state. Heavy emphasis has been placed on the research and development aspects of the industry as is evidenced by the establishment of the multi-million dollar non-profit enterprise, the Industrial Technology Institute located in Ann Arbor. Considerable controversy exists as to whether or not this thrust in robotics will serve to rebuild the economic base of the State. Many, especially manufacturers, tell us that the industry is small and will remain so.

The Upjohn Study. To provide clarification on the impact of robotics on human resources in Michigan, the W.E. Upjohn Institute for Employment Research conducted a study completed in 1982.[8] Its focus was on job displacement versus job creation as a result of robots. The study defines job displacement as the elimination of particular jobs, not the layoff of individual workers. To summarize its findings: By the end of 1982, approximately 6800 to 7000 robots were operating in U.S. factories. Employment in U.S. robot manufacturing is roughly 2000 workers nationwide today. By the year 1990, the total industrial robot population in the U.S. will be somewhere between 50,000 and 100,000 units.

Over two-thirds of the workers in robot manufacturing are in the traditional white collar areas of professional, technical, administrative, sales, and clerical workers; only one-third are in the traditional blue collar areas of skilled craft workers, production operatives, and laborers.

It is estimated that in Michigan robots will eliminate between 13,500 and 24,000 jobs by the year 1990. Between 30 and 40% of production paint jobs will be eliminated. The report says job displacement due to robots will not be a general problem before 1990. In other words, the unemployment Michigan is facing now is not a result of the use of robots.

By 1990, the creation of 5,000 to 18,000 jobs in Michigan is foreseen in four broad areas: (1) robot manufacturing; (2) direct suppliers to robot manufacturing; (3) robot systems engineering; and (4) corporate robot users. Michigan will provide 20 to 40% of robot production in the U.S. The largest single occupational group of jobs created by robotics will be technicians. Technicians are those individuals with training or experience to test, program, install, troubleshoot, or maintain industrial robots. Most will be trained in two-year programs offered by community colleges. Relatively large numbers of electrical, mechanical, and indsutrial engineers--900 to 3500--will be needed, although Michigan's production of engineering graduates has been declining for the last two decades.

The most remarkable impact of robotics is what the study calls the skill-twist that emerges when the jobs eliminated are compared to the jobs created. The jobs eliminated are semi-skilled or unskilled, while the jobs created require significant technical background. In terms of the number of workers displaced by industrial robots, as well as the jobs created, it appears rather small and insignificant when compared to the over 750,000 Michigan workers currently unemployed. It can be concluded that robotics is not likely to solve Michigan's unemployment problem.

A High Tech State. How does Michigan compare in its efforts to become a high technology state? In June, 1982 a report was issued by the Joint Economic Committee of the U.S. Congress on the location of high technology firms and regional economic development.[9] According to the report, in both 1975 and 1979, 83% of the Nation's high technology jobs were located in 24 states, and collectively they accounted for approximately 82% of the net increase in high tech jobs in the United States. Michigan was one of the 24 states identified, ranking 18th with a 25.24% increase in high tech jobs, from 73.7 thousand in 1975 to 92.3 thousand in 1979. (The national growth average was 24.4%.) Nationwide in 1979 Michigan accounted for 2.54% of high tech employment, a 1.2% increase over 1975, as compared to the leading high tech states--California with 15.85% of high tech employment, and Massachussetts with 6.13%.

III

The Role of Robotics in Education

What is the influence of robotics on the individual and society? If we look at the total social context, four areas of individual human interaction can be identified--family life, learning life, work life, and leisure life. Thus far, the focus of discussion has been on the transition from an industrial society to an information society, and on the changing nature of work life as a result of robotics and the other new technologies. The other social dynamic to have major impact on us and our evolving information society is education.

In 1973 at the First Conference on Industrial Robot Technology, a paper was presented on the impact of robots on everyday life, which is particularly relevant today.[10] Discussed was the establishment of a creative society, basing individual success not on amount of payment and acquired goods, but rather on self-fulfillment through creative achievements. It was hypothesized that the prolific use of robots would contribute to this happening because they eliminate boring repetitive jobs; eliminate dangerous and uncomfortable work; and reduce the need for long hours of work by humans.

Thring, the author, foresaw robots built able to learn to use tools with exact skill, to coordinate sight and touch sensations--our second generation robots now being developed. He also noted that a robot will never be able to do more ordered and sophisticated tasks than a human has instructed it to do. Even though it will become possible to build a computer as compact, with as many storage units and interconnections as the human brain, and with artificial intelligence commensurate to the intellectual brain of a person, a robot will never be built with an emotional

brain dealing with feelings and attitudes. Nor will one be built that is able to produce its own original creation or invention.

High unemployment of unskilled and semi-skilled workers is inevitable as the use of robots expands. This is further aggravated by the concurrently changing economy from one of perpetual expansion to one of equilibrium. The evolving equilibrium economy is characterized by shortened work hours, redistribution of work assignments, and great expansion of services. With the perpetual demand for individuals to learn and use new information and skills, education provides the key.

With our Nation's shift to an equilibrium economy, job growth has moved increasingly to the so-called "knowledge workers". Jobs are of greater diversity, interest, and challenge, with information occupations encompassing lawyers, teachers, engineers, computer programmers, systems analysts, secretaries, technicians, social workers, doctors, nurses, librarians, the list goes on. The resource considered essential in this evolving information/service economy is educated people. Nowhere is this more evident than in the robotics industry with its demand for engineers and qualified technicians.

The OTA Report

Recently, the Office of Technology Assessment of the U.S. Congress released its report addressing the dilemma facing American education in its efforts to respond to the information revolution and its dramatic effects on our society. The information technologies encompassed by the report include cable, satellite communication, digital telephone networks, broadcast technologies, computers, storage technologies, video technologies, video disks, information services such as videotex and teletext, electronic conferencing, and information networks. Robotics represents the integrated application of several information technologies.

The report, Informational Technology and Its Impact on American Education, presents the following findings.[11] (1) The growing use of the information technologies is creating new demands for education and training in the United States. (2) The potential for economic and social penalty for not responding to those demands is increasing. (3) The information revolution is creating new stresses on many societal institutions, public schools in particular. (4) Information technology is already playing an important role in providing education and training in certain sectors. (5) Information technology holds great promise for responding to our society's education and training needs, and it is likely to become a major vehicle for doing so within the next 20 to 30 years.

In discussing the social changes resulting from the new information technologies, several significant developments having a profound effect on our education system are identified:

- an increase in the level of education that individuals need to participate effectively in society
- an extension of the period of time during which individuals can and need to be educated
- an increase in the diversity of the educational clientele and thus an increase in the diversity of the demand for education
- a decline in public resources for education, resulting in part from
  - an increase in the cost of producing education
  - a questioning of the public benefits associated with education
  - a loss of confidence in the institutions providing education
- the emergence of new institutions that under new circumstances find it profitable to market education
- the development of new information technologies that allow educational institutions to provide specialized services to specific sectors of the market.[12]

The report's predictions for the future of the American public school system are not optimistic. As to the application of information technology in education and training, the report cautions its premature and over-zealous use. It points out that we do not know enough about the educational and

psychological effects of technological approaches to instruction; we do not know enough to determine how the new technologies can best benefit the learner; we do not know enough to predict the possible negative effects of its use. Great care must be taken in introducing these new technologies into education.

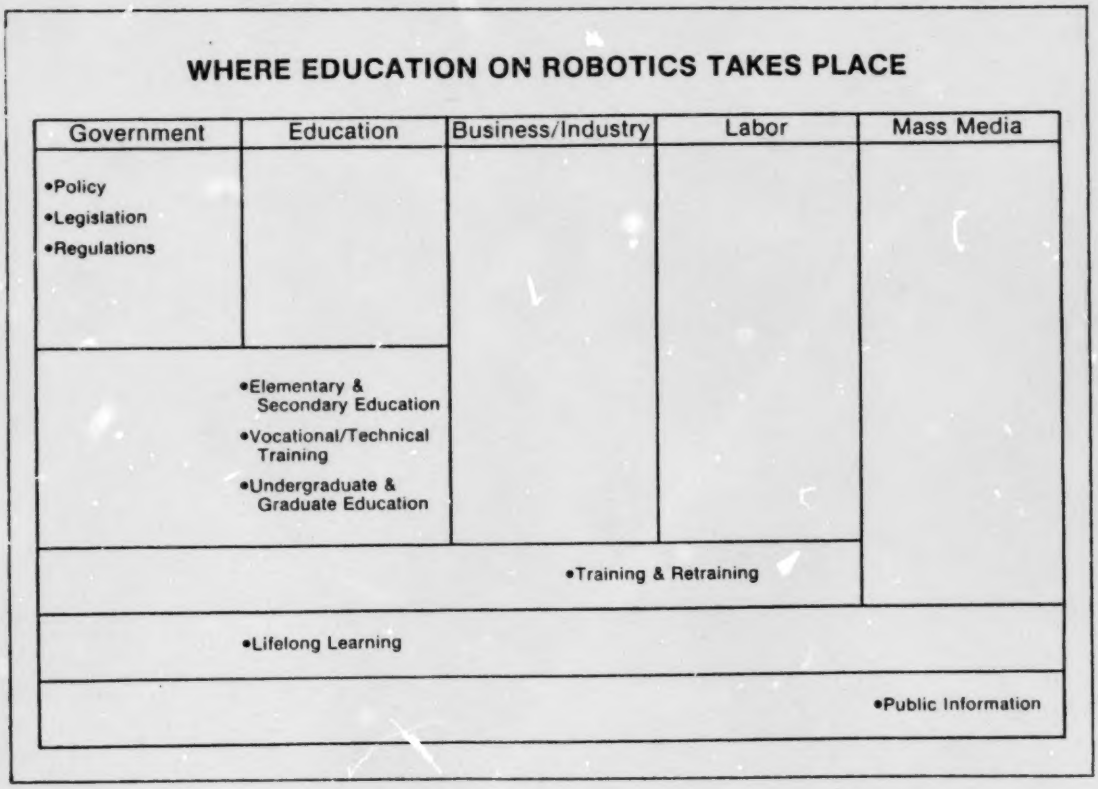
The Education Picture

By looking at where education for robotics is taking place, the expanding role of education and the growing variety of institutions providing education and training becomes evident. Technical skills development at the postsecondary level is not the only dimension of education for robotics. Robotics education actually begins in elementary school where learning concentrates on the development of the basic skills and other cognitive learning skills germane to robot technology. In high school these skills are further developed and conscious preparation for entering the workforce begins. But schools are not the only places where education and training occur.

Five sectors of society provide education-related services pertinent to robotics and the other high technologies. See Figure 5. Each sector has primary responsibility for only certain aspects of the educating process, although those functions do overlap.

Government. The government, federal and state, is a major force in providing education and training pertinent to robotics. Its primary functions revolve around public policy, legislation, and regulations. Implicit is the support for educational activities provided as a result of legislative mandates. Three current pieces of legislation are particularly important to this discussion.

Figure 5



1. The Job Training Partnership Act, replacement for CETA, is to be implemented in October, 1983. The new law requires local communities to work as partners with private industry to provide job training for unemployed and displaced workers. Michigan will receive $140 million through this legislation.

2. The Math and Science Bill, pending legislation, is to be administered by direct grants through the National Science Foundation and through state grant formulas by the U.S. Department of Education. This legislation, if approved, may go into effect as early as this summer in response to the growing shortage of qualified math and science teachers

and our declining capability in those areas of instruction in middle and secondary schools.

3. The American Defense Education Act, the most recent legislative action, has just been reintroduced by Senator Gary Hart of Colorado. This piece of legislation calls for more assistance in mathematics, science, guidance and counseling, communications, foreign languages, new high technology, and computer literacy. The bill would establish a national program to improve the quality of instruction; provide incentive payments to school districts, and establish educational research programs in various areas.

Education. The primary providers of educational services are public, private, and proprietary education institutions. Its primary responsibilities focus on elementary and secondary education, vocational and technical education, and undergraduate and graduate education. Also, lifelong learning is most often placed in its domain. Where robotics and the other high technologies are concerned, postsecondary education has dominated the scene with most of the technical training being conducted by community colleges and professional training at universities and four-year institutions of higher learning. Elementary schools have yet to be recognized as sites for technological literacy to be addressed, with secondary schools not much better, even though the computer literacy bandwagon is riding high. Vocational and technical education for the most part continues to focus on technical skills development and is steadily eroding due in large part to technological obsolescence--unable to afford necessary capital investments in the new technologies, and like elementary and secondary education, unable to maintain an updated teaching staff.

Business/Industry and Labor. The educational efforts of business/industry and labor concentrate on work-related training and retraining. Both are heavily involved as cosponsors and initiators. Increasingly industry is finding it necessary to provide continuing education for its staff members, as well as retraining for those displaced due to technological innovation. Vulnerable to high technology firms, labor too is placing increasing emphasis on the training and retraining of its membership for work in a high tech society.

Training by business/industry tends to be directed to six staff groups: production line workers (unskilled and semi-skilled); skilled trades; technical (engineering, data processing, research and development); management; supervisory (first-line); and professional. The primary means by which education activities are provided are by contract with educational institutions; through cooperatively designed and implemented programs with educational institutions; and through programs designed, operated, and sponsored by the companies themselves. The majority of educational programs provided by labor fall into three categories: (1) college programs in labor studies; (2) apprenticeship programs; and (3) special programs of a continuing education nature on subjects such as labor law, collective bargaining techniques, and parliamentary procedures, as well as special programs on preapprenticeship training, basic skills education, and vocational exploration.[13] As to robots, when they enter the workplace an initial orientation is frequently provided by the robot manufacturer, while the retraining of workers who will interact with the robots on a daily basis is left up to the user firms.

Business/industry is expanding its role dramatically as a provider of education and training. Based on the New York Times Survey of Continuing Education conducted in 1981, 300 colleges may close during this decade as a result of the declining number of high school graduates, while 300 company-sponsored institutions of higher learning, which focus on highly specialized corporate needs, will begin operation.[14]

Mass Media. The mass media is the primary provider of public information, an educational service frequently overlooked. Whether through entertainment, news broadcasting, special educational programming, or commercial advertising, the mass media educates the American public. Its influence is powerful, yet most of its educational effects, to date, appear to be non-intentional. Until the information revolution, much of its impact has been on a passive, inactive audience. As the application of information technologies becomes more interactive, the capacity for audience participation expands dramatically.

We have had three great media in human history--printed matter, film and television, and the computer. Telecommunications encompasses all three. For example, two telecommunications cables are in many homes today--the telephone cable and the television cable. One television cable can carry forty television channels at reasonable cost. An average American home has the television turned on for an average of 6½ hours per day. Using a television channel, which has 100,000 times the transmission capacity of a teleprinter, prodigious quantities of print could be delivered by telecommunications to the home. The user could give the computer a list of types of news or subjects of interest he or she wants. The burgeoning cable television industry is having difficulty finding

ways to fill its channels.[15] (Might this be an assignment for the educator community?)

The mass media has also influenced our perception of robots and robotics. We need only to view the film Star Wars for one interpretation, or the news casting of the Robot VI Convention last year, which focused on televising the one humanoid display robot, over the nearly 200 industrial robots on exhibit.

Challenges Facing Public Education

For the robotics industry, the preparation and training of its knowledge workers has focused on postsecondary education provided by higher education. Another dimension of education important to the industry has been given inadequate attention, namely schooling, kindergarten through grade twelve. Schools provide the basic preparation for our workers of the future and should be cultivating a workforce responsive to our rapidly advancing technological society. Unfortunately, this does not seem to be happening. Rather than narrowing, the gap between education and technology continues to grow. At the crux of the problem is the issue of relevancy. The issue is a complex one relating to our society in transition, which highlights the interrelatedness of technology, employment and education. The robotics industry provides a prototype for the impact of technology on society, and a context for examining the relevancy of schooling in preparing individuals to function within that society.

Today's schools are faced with two critical questions: What are appropriate goals for education in the twenty-first century?, and What do students entering a knowledge-intensive era need to learn? As schools strive to become technologically relevant, all sorts of challenges arise. The reexamination and redesign of preservice teacher education, teacher

certification and the evaluation of student performance appear to be inevitable. In addition to the myriad of economic problems public schools are facing, educators are confronted with other critical issues brought on by the information revolution. Among them--introducing more technology into education, changing traditional delivery systems, and entering into new arrangements with business/industry and government.

While the traditional basics of reading, writing, and computation are being pursued with great vigor, and indeed are more necessary than ever, a reality we face is that even if all pupils were achieving to the fifth grade skill level, that level of achievement is insufficient for entry level employment in knowledge occupations. While computer literacy is rapidly emerging as a new basic skill, the need for a new set of essential skills, in addition to the basic skills, is becoming increasingly evident. The new essential skills focus on process rather than subject matter content. They include: (1) critical thinking, (2) problem solving, (3) creativity, (4) application, (5) synthesis, (6) decision making, (7) communication, and (8) evaluation and analysis--skills essential for functioning in a knowledge society.

How can schools incorporate the new essential skills? A starting point might be the modification of the general education curriculum at both elementary and secondary levels. This might be accomplished in several ways:

1. By integrating the new essential skills into the general education curriculum as it currently exists, by intentionally relating process content to subject matter. For example, <u>creativity</u>, as a focus on Art; <u>synthesis</u>, as a focus of American History; <u>application</u>, as a focus of Economics.

2. By developing new requirements for the general education curriculum by adopting a new series of courses on units of learning which highlight the new essential skills. Courses such as, "Living with Electronics"; "The Impact of Computers on Society"; or "Values, Technology, and Society".
3. By changing the context of the curriculum from subject matter content to process content, in which the subject matter, i.e., information, is used to facilitate the means of a process. For example, using a class debate to discover Communication; or a chemistry experiment to discover Critical Thinking.

Particularly important in this effort are the curriculum specialists, and they will need to be prepared, especially in the process content of the new essential skills. Teachers, administrators and university professors also will need training.

Another concern is the renewed emphasis on science and mathematics education as the answer to the ills of American education. While the shortage of good math and science teachers is real and needs to be remedied, placing the burden of responsibility for improving the quality of public education on these two areas does not get at the core of the problem. The resistance to viewing technology as a tool, as an enhancement to learning is a dilemma which needs resolution. Human-machine interface is a problem recognized by the manufacturing industry, it is also a problem we educators face in schools.

Along with the other knowledge workers in our information society, lifelong learning will be an essential aspect of the work life of educators. Massive and compulsory inservice education will be necessary to maintain technological relevancy in our education enterprise. Faced

with increasingly competitive and diverse institutions marketing education for profit, public schools can anticipate dramatic changes in structure and function. The immediate concern is for educators to become technologically relevant.

What robotics demands in the way of knowledge and skills is commensurate with those required of the other high technologies. Emphasis is on the new essential skills, supported by the traditional basics and integrated with the information technologies. In the not too distant future, robots may very well be used to perform many of the traditional teaching-related tasks--taking attendance, grading tests, giving assignments, reviewing materials, presenting material--while teachers are freed to develop the socialization and interpersonal relations skills of their students. The capacity already exists for the computer to provide subject matter content.

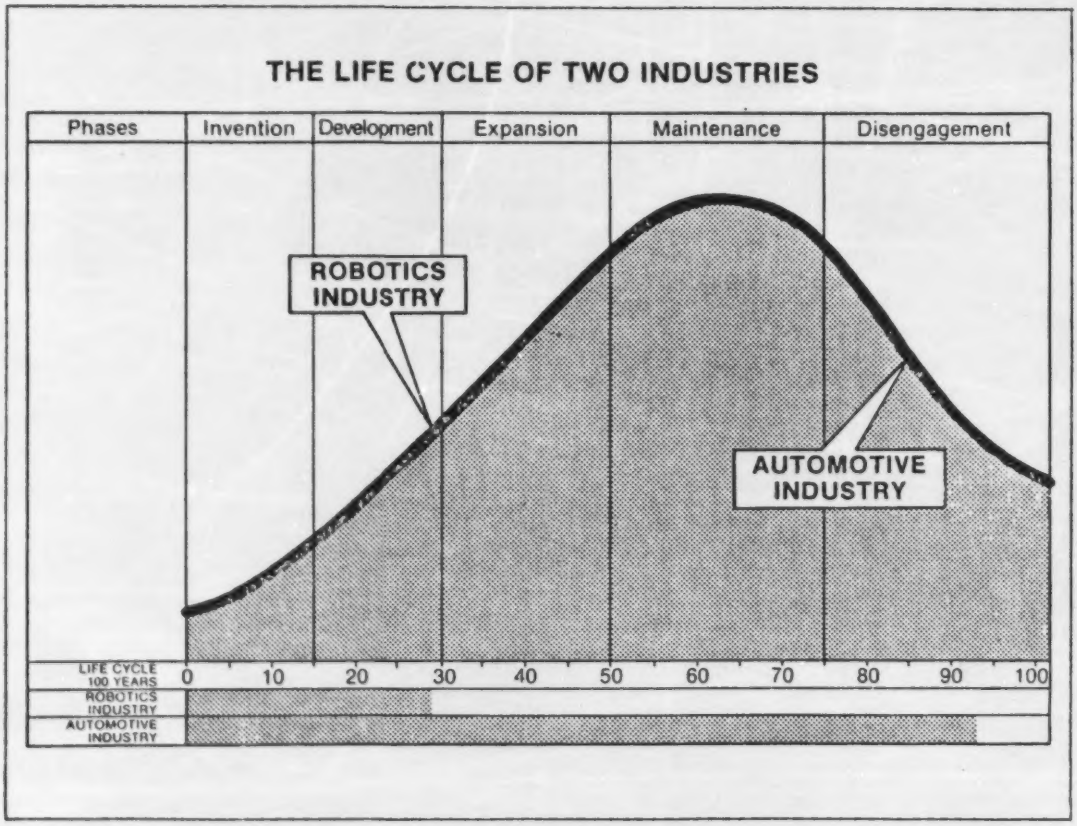
High Tech Firms and Public Schools

To better understand the potential impact of robotics on our future and its relationship to our lives, it might be helpful to compare the evolution of the automotive industry to that of the robotics industry. Interestingly, their development seems to parallel that of the human life span--but then both industries are the inventions of humans.

Plotted on a 100 year cycle, five phases of development emerge. See Figure 6.

Phase I: Invention. This first phase highlights invention--the first automobile, the first robot--and includes the establishment of the first company to manufacture the new invention.

Figure 6



Phase II: Development. Development is the focus of the second phase when enterpreneurs in these new industries take action. Many new, small automobile/robot manufacturing firms appear. Competition is great. Many models are on the market. The robotics industry is at this phase.

Phase III: Expansion. Expansion marks the third phase. Changes occur in company organization as smaller firms are bought out. Fewer companies dominate more and more of the market. As consumer skepticism dwindles, so too does product cost as demand for the automobile/robot mounts.

Phase IV: Maintenance. This fourth phase, akin to middle age, is characterized by maintenance of automobile/robot production and its share of the marketplace. A few major companies are manufacturing the majority of automobiles/robots for which there is a strong and constant consumer demand.

Phase V: Disengagement. In this fifth phase, as with disengagement in human life, the industry is in obvious decline. The product is represented by new more advanced versions. Consumer demand for the old product wanes. As demand decreases, so too does production. The industry may either pass into posterity or restructure with new images and inventions, thereby giving birth to a new cycle. The automotive industry is at this phase.

Currently the robotics industry is in its development phase approaching nearly thirty years of evolution with a bright and prosperous future still ahead. On the other hand, the automotive industry is approaching 80 years of evolution, and having passed its peak appears to be evolving into a new configuration. It is worth noting that both public education and labor have been following life cycles commensurate with that of the automotive industry.

Two particularly penetrating case studies on high technology and education were developed by Elizabeth Useem of Northeastern University. One concentrates on Silicon Valley in California, the other on Route 128 in Massachussetts.[16,17] Both reports reveal the strained relationship which currently exists between the high technology industry and public education. High tech firms with immediate needs dominating, which cannot be met by schools, hold public education in low regard; schools, resenting the short-sighted focus of high tech firms, hold them in dis-

dain. Several factors contribute to those attitudes. (1) The very dynamism, innovation, and rapid growth characterizing most high technology firms undermine attempts at extra-institutional ties. (2) The rapid technological change, the newness of many companies, frequent changes in company organization, the unpredictability of workforce needs, and the constantly changing market lead to short-term planning cycles in the industry. (3) School officials generally see additional government financial aid as a solution to major educational problems; leaders in high technology firms espousing the conservative "small government" philosophy oppose new government spending in domestic areas. (4) The two institutions are at vastly different points in history to interact productively--public education facing declining enrollments, test scores, and financial support; burgeoning high tech industry responding to exploding growth and competition. Developmentally speaking, the high tech industry, (robotics included), now in its late adolescence/early adulthood, is unready to collaborate and provide aged public education with the interaction it seeks and so desperately needs to recycle.

Because it is still small and in the early stages of development, the robotics industry provides education with a representation of the high tech industry in microcosm. Through it we can see the integration of several information technologies, i.e., the computer, fiber optics, video technologies, etc. The industry demands knowledge workers and that demand is expanding. The occupations that are emerging in response to the industry's needs call upon the new essential skills. And those individuals who have the requisite knowledge and skills, with the acknowledgement that they will need life long retooling can look forward to a productive place in our information society. The question we are now

faced with is "How will public education respond? To close the gap between technology and education will schools redefine the basics and the core curriculum? Redesign the general education curriculum? Redirect teacher education? Restructure teacher certification? Undertake universal inservice at all levels? If not, what can public schools do to effectively prepare individuals to function as contributing members of our information society?

References

[1]Cetron, Marvin and Thomas O'Toole. "Careers With a Future: Where the Jobs Will Be in the 1990s," The Futurist (June, 1982), 11-19.

[2]Weil, Robert, ed. The Omni Future Almanac. Chapter 5. New York: Harmony Books, 1982.

[3]Sanoff, Alvin P. and John J. McCann. "Where U.S. Is Going: Signposts From Census," U.S. News & World Report. (November 22, 1982), 51-53.

[4]Ayres, Robert and Steve Miller. "Industrial Robots on the Line," Technology Review (May/June, 1982) 35-46.

[5]Ibid., p. 43.

[6]Cetron, Marvin and Thomas O'Toole. Encounters with the Future: A Forecast of Life in the 21st Century. New York: McGraw-Hill, 1982, p. 248.

[7]Conigliaro, Laura. "Trends in the Robotics Industry," Technical Paper. Robot VI Conference Proceedings. Dearborn, Michigan: Society of Manufacturing Engineers, 1982.

[8]Hunt, H. Allan and Timothy L. Hunt. Robotics: Human Resource Implications for Michigan. Preliminary Report. Kalamazoo, Michigan: W.E. Upjohn Institute for Employment Research, December, 1982.

[9]Joint Economic Committee. Location of High Technology Firms and Regional Economic Development. Washington, D.C.: U.S. Government Printing Office, 1982.

[10]Thring, M.W. "The Impact of Robots in Everyday Life," Proceedings of the First Conference in Industrial Robot Technology. University of Nottingham, United Kingdom (March 27-29, 1972) pp. R19-217 - R19-222.

[11]Office of Technology Assessment. Informational Technology and Its Impact on American Education. Washington, D.C.: U.S. Congress, 1982.

[12]Ibid., p. 69

[13]Ibid., Chap. 6

[14]Brickell, Henry M. and Carol B. Aclonian, "The Colleges and Business Competition," New York Times Survey of Continuing Education, August 30, 1981.

[15]Martin, James. Telematic Society: A Challenge for Tomorrow. 2 ed., Englewood Cliffs, N.J.: Prentice-Hall, 1981.

[16]Useem, Elizabeth. "Education and High Technology Industry: The Case of Silicon Valley," Boston, Mass.: University of Massachussetts, August, 1981. (Unpublished)

[17]_____. "Education in a High Technology World: The Case of Route 128," Boston, Mass.: Northeastern University, June, 1982. (Unpublished)